PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

(Chapter II of the Patent Cooperation Treaty)

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference I3192-PCT	**FOR FURTHER ACTION**	See Form PCT/IPEA/416
International application No. PCT/EP2004/014816	International filing date *(day/month/year)* 24.12.2004	Priority date *(day/month/year)* 24.12.2003

International Patent Classification (IPC) or national classification and IPC
H03B9/14, H03B5/40, H01L41/00, G10K11/36, G01R33/02, H03H9/42, H03H9/64

Applicant
INTERUNIVERSITAIR MICROELEKTRONICA CENTRUM VZW e.a

1. This report is the international preliminary examination report, established by this International Preliminary Examining Authority under Article 35 and transmitted to the applicant according to Article 36.
2. This REPORT consists of a total of 5 sheets, including this cover sheet.
3. This report is also accompanied by ANNEXES, comprising:
   a. ☒ *sent to the applicant and to the International Bureau)* a total of 4 sheets, as follows:
      ☒ sheets of the description, claims and/or drawings which have been amended and are the basis of this report and/or sheets containing rectifications authorized by this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions).
      ☐ sheets which supersede earlier sheets, but which this Authority considers contain an amendment that goes beyond the disclosure in the international application as filed, as indicated in item 4 of Box No. I and the Supplemental Box.
   b. ☐ *(sent to the International Bureau only)* a total of (indicate type and number of electronic carrier(s)) , containing a sequence listing and/or tables related thereto, in computer readable form only, as indicated in the Supplemental Box Relating to Sequence Listing (see Section 802 of the Administrative Instructions).

4. This report contains indications relating to the following items:

☒	Box No. I	Basis of the opinion
☐	Box No. II	Priority
☐	Box No. III	Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
☐	Box No. IV	Lack of unity of invention
☒	Box No. V	Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
☐	Box No. VI	Certain documents cited
☐	Box No. VII	Certain defects in the international application
☐	Box No. VIII	Certain observations on the international application

Date of submission of the demand	Date of completion of this report
18.10.2005	06.04.2006

Name and mailing address of the international preliminary examining authority:

European Patent Office - P.B. 5818 Patentlaan 2
NL-2280 HV Rijswijk - Pays Bas
Tel. +31 70 340 - 2040 Tx: 31 651 epo nl
Fax: +31 70 340 - 3016

Authorized Officer

Stichauer, L

Telephone No. +31 70 340-1959

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.
PCT/EP2004/014816

Box No. I Basis of the report

1. With regard to the **language**, this report is based on the international application in the language in which it was filed, unless otherwise indicated under this item.

   ☐ This report is based on translations from the original language into the following language , which is the language of a translation furnished for the purposes of:
   - ☐ international search (under Rules 12.3 and 23.1(b))
   - ☐ publication of the international application (under Rule 12.4)
   - ☐ international preliminary examination (under Rules 55.2 and/or 55.3)

2. With regard to the **elements*** of the international application, this report is based on *(replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report)*:

   Description, Pages

   1-21 as originally filed

   Claims, Numbers

   1-32 received on 18.10.2005 with letter of 18.10.2005

   Drawings, Sheets

   1/10-10/10 as originally filed

   ☐ a sequence listing and/or any related table(s) - see Supplemental Box Relating to Sequence Listing

3. ☐ The amendments have resulted in the cancellation of:
   - ☐ the description, pages
   - ☐ the claims, Nos.
   - ☐ the drawings, sheets/figs
   - ☐ the sequence listing *(specify)*:
   - ☐ any table(s) related to sequence listing *(specify)*:

4. ☐ This report has been established as if (some of) the amendments annexed to this report and listed below had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).
   - ☐ the description, pages
   - ☐ the claims, Nos.
   - ☐ the drawings, sheets/figs
   - ☐ the sequence listing *(specify)*:
   - ☐ any table(s) related to sequence listing *(specify)*:

* *If item 4 applies, some or all of these sheets may be marked "superseded."*

Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	1-32
	No:	Claims	
Inventive step (IS)	Yes:	Claims	1-32
	No:	Claims	
Industrial applicability (IA)	Yes:	Claims	1-32
	No:	Claims	

2. Citations and explanations (Rule 70.7):

see separate sheet

Re Item V

Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1 Reference is made to the following document:

D1: S. I. KISELEV ET AL.: "Microwave oscillations of a nanomagnet driven by a spin-polarized current" NATURE, vol. 425, 25 September 2003 (2003-09-25), pages 380-383, XP002329287

2 The document D1 is regarded as being the closest prior art to the subject-matter of independent claims 1 and 29, and shows (the whole document):

"*A device for generating an oscillating signal, the device comprising a means for providing a current of spin polarised charge carriers, a magnetic excitable layer adapted for receiving said current of spin polarised charge carriers thus generating an oscillating signal with a frequency* v_{osc} *and a means for interacting with said magnetic excitable layer to thereby select said oscillation frequency.*"

"*A method for generating oscillations, the method comprising providing a current of spin polarised charge carriers, thus generating an oscillating signal with an oscillation frequency* v_{osc} *by interaction between said current of spin polarised charge carriers and a magnetic excitable layer, and controllably tuning said oscillation frequency* v_{osc} *by inducing an interaction between a means and said magnetic excitable layer.*"

The subject-matter of claims 1 and 29 differs from these known device and method, respectively, in that

said means for interacting are integrating means and they are different from said means for providing a current of spin polarised charge carriers .

The subject-matter of claims 1 and 29 is therefore new (Article 33(2) PCT).

The problem to be solved by the present invention may be regarded as *how to provide fully integrated RF circuits, in which all essential elements for selecting or tuning a frequency of the oscillations are present in a united way, i.e. structurally or functionally, and which furthermore are able to set or tune the peak frequency of the oscillation while keeping the quality factor and the stability of the oscillation maximal, i.e. as high as possible, and with minimal additional power consumption* (see present specification, page 3, lines 8-13).

The solution to this problem proposed in claims 1 and 29 of the present application is considered as involving an inventive step (Article 33(3) PCT) for the following reasons: in the closest prior art, the frequency of the oscillations is tuneable either by changing the amplitude of the spin polarized current (type 1), or by using an external magnetic field (type 2). Hence, D1 discloses either an integrating means for interacting which is however not different from said means for providing a current of spin polarised charge carriers (type 1), or it discloses a means for interacting which is different from said means for providing a current of spin polarised charge carriers but it is not integrated (type 2). Therefore, according to D1, a fully integrated RF circuit is not provided (type 2) and/or an additional power consumption is required (type 1 and 2 each).

3 Claims 2-28 and 30-32 are dependent claims and as such also meet the requirements of the PCT with respect to novelty and inventive step.

4 The present application relates to current induced oscillators, modulators and filters etc., which are based on the "spin torque" effect, and as such satisfies the requirement of industrial applicability (Article 33(4) PCT).

CLAIMS

1.- A device for generating an oscillating signal, the device comprising

- a means for providing a current of spin polarised charge carriers
- a magnetic excitable layer adapted for receiving said current of spin polarised charge carriers thus generating an oscillating signal with a frequency ν_{osc}, and
- an integrated means, different from said means for providing a current of spin polarised charge carriers, for interacting with said magnetic excitable layer to thereby select said oscillation frequency.

2.- A device according to claim 1, wherein said integrated means for interacting with said magnetic excitable layer is a means for controllable tunable interacting with said magnetic excitable layer such that a controllable tuning of said oscillation frequency is achieved.

3.- A device according to any of claims 1 to 2, wherein said interacting comprises performing magnetic interactions comprising inducing mechanical stress in said magnetic excitable layer.

4.- A device according to the previous claim, wherein said magnetic interactions are interface interactions.

5.- A device according to any of claims 1 to 4, wherein said interacting comprises performing any of magnetostatic interactions and exchange bias interactions.

6.- A device according to any of claims 1 to 5, wherein said magnetic excitable layer is a ferromagnetic semiconductor layer and said interacting comprises applying an electric field over said ferromagnetic semiconductor layer.

7.- A device according to any of claims 1 to 6, comprising a means for generating a magnetic bias field to bias the magnetic excitable layer.

8.- A device according to claim 7, wherein said means for generating a magnetic bias field is an anti ferromagnetic layer which is in at least partial magnetic contact with said magnetic excitable layer

9. - A device according to claim 8, comprising a means for generating stress upon said anti ferromagnetic layer.

10.- A device according to any of claims 7 to 9, wherein said means for generating said magnetic bias field comprises an element of ferromagnetic material which is magnetostatically coupled to said magnetic excitable layer.

11.- A device according to claim 10, further comprising a means for changing the geometric distances between said magnetic excitable layer and said ferromagnetic element.

12.- A device according to claim 11 wherein said means for changing the geometric distances consists of a piezoelectric layer or suspended structure.

13.- A device according to any of claims 1 to 12, wherein said integrated means for interacting with said magnetic excitable layer comprises an interacting layer, which is coupled magneto-elastically and/or magneto-statically and/or via the exchange bias effect to said magnetic excitable layer.

14.- A device according to claim 13, wherein said interacting layer is a piezoelectric layer.

15.- A device according to any of claims 13 to 14, wherein said interacting layer is an antiferromagnetic layer.

16.- A device according to any of claims 13 to 15, further comprising a surface acoustic wave generating means which can generate a Surface Acoustic Wave in said interacting layer.

17.- A device according to any of claims 13 to 16, wherein said interacting layer is a structural part of the Surface Acoustic Wave generating means.

18.- A device according to any of claims 16 to 17, wherein said Surface Acoustic Wave generating means generates a Surface Acoustic Wave in said interacting layer, which has a frequency essentially equal to the magnetic resonance frequency of said excitable layer, or an integer multiple thereof.

19.- A device according to any of claims 13 to 18, wherein at least 2 electrodes are provided on a surface or inside said interaction layer, which allow to induce stress in said interaction layer by putting an electrical potential difference over them.

20.- A device according to any of claims 13 to 19, comprising a means for generating stress in said interaction layer by physical force or pressure build up.

21.- A device according to any of claims 1 to 20, wherein said means for providing a current of spin polarised charge carriers is abutting on said magnetic excitable layer and comprises an electrode, a spin polarisation means and a current confinement structure.

22.- A device according to claim 21, wherein said means for providing a current of spin polarised charge carriers comprises a fixed layer with a constant magnetic polarisation through which the current is passing, before entering into the excitable layer.

23.- A device according to claim 22, wherein the fixed layer and excitable layer are separated by an interlayer to magnetic separate both layers.

24.- A device according to any of claims 1 to 23, further comprising a readout structure, which measures the excitation caused by the spin polarised current passing through said magnetic excitable layer or a related or equivalent parameter.

25.- A device according to any of claims 1 to 24, further comprising a readout structure, which measures the magneto-resistance or a related effect, generated by combination of the fixed layer and the magnetic excitable layer.

26.- A device according to any of claims 1 to 25, further comprising a readout structure, which comprises a piezoelectric measurement layer, which converts the precessional movement of the excitable layer into an electrical signal.

27.- A device according to any of claims 1 to 26, further comprising a readout structure, which measures the resistance change by measuring the AC signal between at least 2 electrodes in electrical contact with said excitable layer.

28.- A device according to any of claims 1 to 27, further comprising a readout structure, which measures the change of resistance or voltage in a lateral geometry.

29.- A method for generating oscillations, the method comprising

- providing a current of spin polarised charge carriers, thus generating an oscillating signal with an oscillation frequency ν_{osc} by interaction between said current of spin polarised charge carriers and a magnetic excitable layer
- controllably tuning said oscillation frequency ν_{osc} by inducing an interaction between an integrated means, different from said means for providing a current of spin polarised charge carriers, and said magnetic excitable layer.

30.- A method according to claim 29, wherein inducing an interaction between an integrated means and said magnetic excitable layer comprises any of inducing mechanical stress in said magnetic excitable layer, inducing exchange bias interactions and inducing magnetostatic interactions.

31.- A method according to any of claims 29 to 30, said magnetic excitable layer being a ferromagnetic semiconductor layer, wherein inducing an interaction is performed by applying an electric field over said ferromagnetic semiconductor layer.

32.- A method for reading out a magnetic element, the method comprising

- providing a current of spin polarised charge carriers, thus generating an oscillating signal with an oscillation frequency ν_{osc} by interaction between said current of spin polarised charge carriers and a magnetic excitable layer
- controllably tuning said oscillation frequency ν_{osc} by inducing an interaction between an integrated means, different from said means for providing a current of spin polarised charge carriers, and said magnetic excitable layer
- measuring an excitation, or a related or equivalent parameter, said excitation being caused by said spin polarised charge carriers.